KIRTLANDIA®

THE CLEVELAND MUSEUM OF NATURAL HISTORY

CLEVELAND, OHIO NUMBER 26

LIPID DEPOSITION IN NESTLINGS OF THE HOUSE SPARROW AND RED-WINGED BLACKBIRD

TIMOTHY O. MATSON AND LARRY D. CALDWELL

Cleveland Museum of Natural History
Michigan State University

ABSTRACT

It is well known that lipid depots serve as an energy source for birds during migratory flight. Furthermore, studies by Wolfson (1954), Odum and Connell (1956), King and Farner (1959) and others have shown that lipid volumes vary from one phase of the annual life cycle to the next. Little of the work on avian lipids to date, however, has been concerned with nestlings. According to Brenner (1964), nestling Red-winged Blackbirds (*Agelaius phoeniceus*) deposit about 75 mgms per day. Brenner's measurements were made from body organ sections and the major lipid depots.

In the spring and summer of 1973 nestlings of the House Sparrow (*Passer domesticus*) and Red-winged Blackbird were collected in Isabella County of central Michigan. The House Sparrow as a nonmigrant serves as a basis of comparison with the Red-wing which is a medium-range migrant. The Red-wing winters in the United States as far south as Florida and Texas.

METHODS

An entire clutch of nestlings was removed at each nest site rather than removing part of a clutch and thus increasing the quantity of nutrient available to the remaining nestlings. We collected 62 House Sparrows and 46 Red-wings. Weights were taken after collection and specimens were frozen in plastic bags until the time of analysis. Nestlings were aged to the nearest day by using the weight and feather tract development criteria of Weaver (1942) and Williams (1940). Each specimen was dissected, the sex determined, and the gut and crop contents removed before fat extraction.

0075-6245/78/1978-0026 $00.50/0

The fat extraction technique involved the use of a food blender with petroleum ether and ethyl alcohol solvents. Each specimen was covered with alcohol and then macerated in the blender for 45 seconds. Petroleum ether was used to wash the residue into a beaker, which was then placed over a steam bath for several minutes. The two-solvent mixture was subsequently filtered through a strainer and filter paper into a separatory funnel. The residue that was trapped in the strainer was again extracted with petroleum ether in the beaker, heated, and filtered through the filtering system a second time. A total of 10-22 volumes of solvent was used relative to body mass for the extraction process. A biphasic system subsequently resulted upon acidification of the two-solvent mixture (Cratin, 1970). The ether phase, containing the fat, was drawn off, whereas the alcohol phase was washed 2-3 times with petroleum ether. All ether phases for each specimen were finally pooled and evaporated to near dryness. The concentrated fat was then transferred to a preweighed aluminum pan for drying over a steam bath. Final drying was achieved in an oven at 115° C for 12-18 hours. The dried weights of the residue on the filter paper and the residue on the strainer combined represents the dry-lean weight or nonfat dry weight. The method of Cratin (1970) when properly applied gives fat values virtually identical to results obtained by the popular Soxhlet method of fat extraction.

Results

Nestling sparrows exhibited a linear relationship between fat and dry-lean weight as expressed by the equation $Y = 0.18X - 0.03$ (Fig. 1, line A). In other words, 0.18 grams of fat were added for each 1.00 gram of dry-lean weight increase in body mass. However, this line of best fit is separable into two stages, with a tendency for the smaller nestlings (Fig. 1, line B) to accumulate fat more slowly than the larger nestlings (Fig. 1, C) which have a dry-lean weight of 2.49 grams or greater ($P < 0.01$ between slopes). Small sparrows exhibited much less variance about the regression than did the large individuals (0.001 and 0.007 respectively). Notice that 2 nestlings in the lower right-hand corner of the figure were very lean when compared to all other nestlings of a similar dry-lean weight. The above 2 nestlings were not included in the calculations of the regression line. Each of the 2 lean nestlings came from a different clutch.

In contrast, the blackbird nestlings were considerably more variable in the rate of fat increment with respect to dry-lean weight (Fig. 1, line D). In spite of the large overall variance in nestling blackbirds, the smallest individuals of both species were very similar. The eight smallest Red-wings ($X = 0.67$ grams) had 0.06 grams of fat. Accordingly, the fat/dry-lean ratio was 0.09 and was

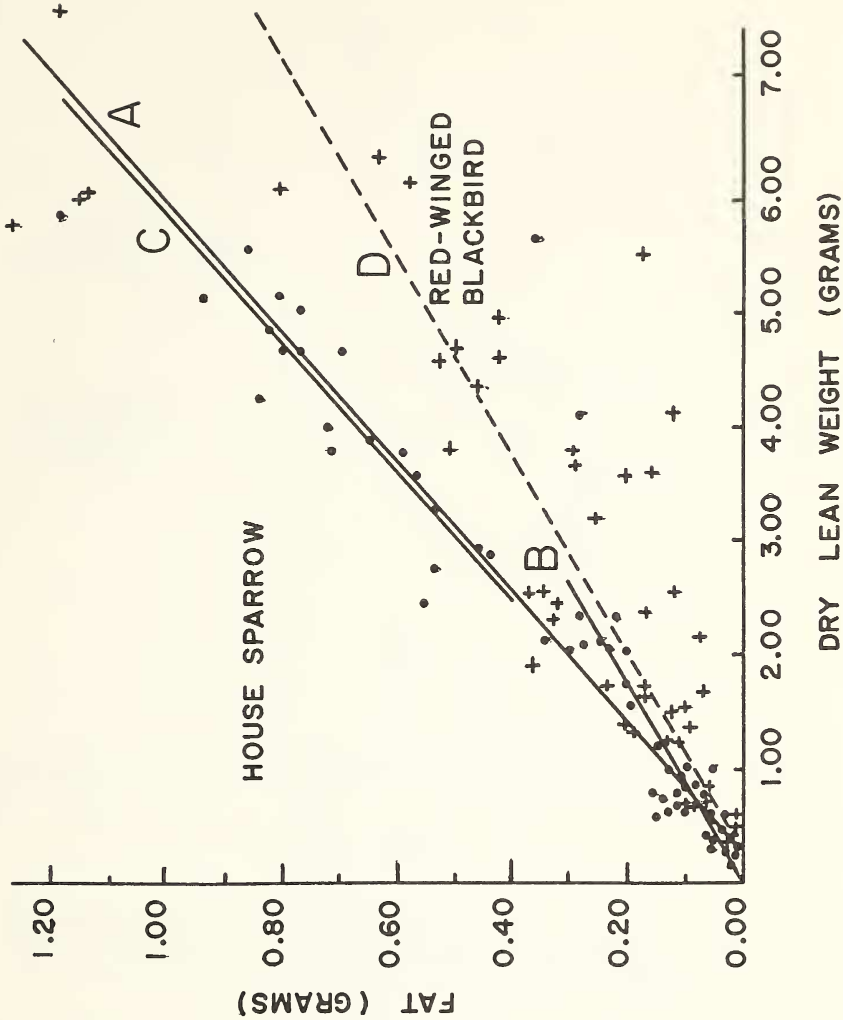

Fig. 1. Changes in the fat content of nestling House Sparrows and Red-winged Blackbirds as a function of dry-lean weight. The equation of the regression line describing all the House Sparrow data (line A) is $Y = 0.18X\text{-}0.03$. The equation for nestling sparrows with a dry-lean weight of less than 2.49 grams (line B) is $Y = 0.12X\text{-}0.00$, whereas the relationship of nestlings 2.49 grams and more in weight (line C) is given by the equation $Y = .17X\text{-}0.01$. The equation of the regression line describing nestling Red-winged Blackbirds (line D) is $Y = 0.12X\text{-}0.04$.

identical to that of the 8 smallest sparrows. The blackbird variance from the regression increased rapidly to a maximum in the 6.00 to 7.50 gram weight class, at which point body fat ranged from 0.58 to 1.15 grams. The overall fat

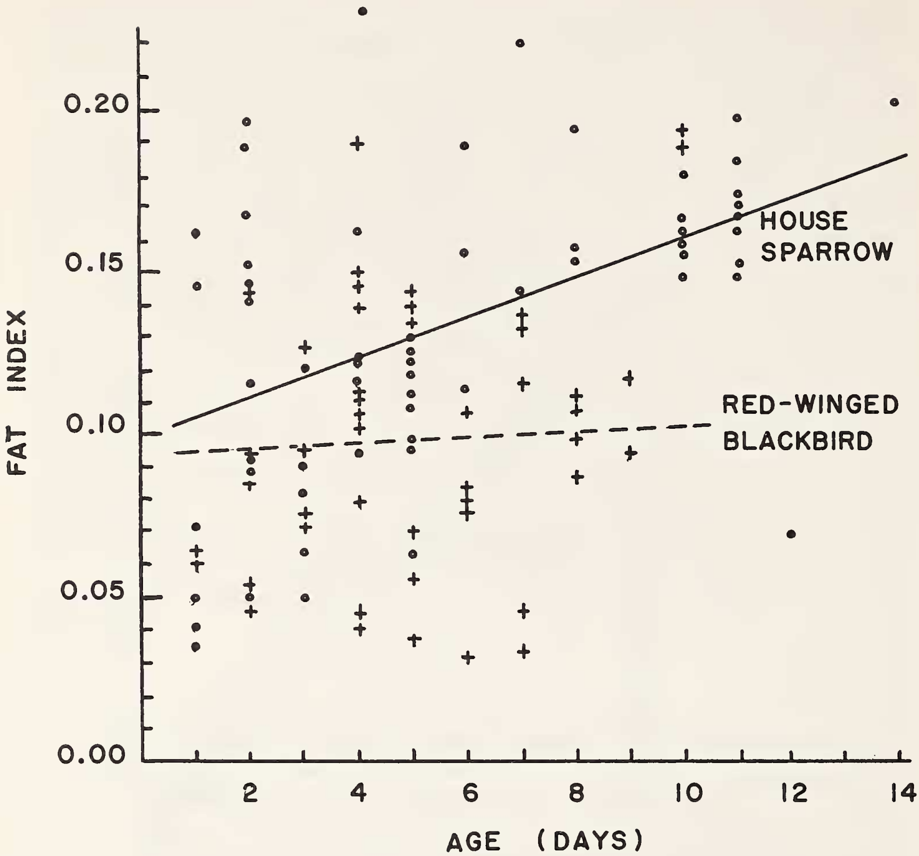

Fig. 2. Changes in the fat index of nestling House Sparrows and Red-winged Blackbirds as a function of age. The equation of the regression line describing the House Sparrow is $Y = 0.01X + 0.10$, whereas the equation describing the blackbird is $Y = 0.01X + 0.08$.

index equation for the blackbird is $Y = 0.12X + 0.02$ with a variance of 0.02. Thus, sparrow nestlings with a regression coefficient of 0.18 had one-third more lipid per gram of body mass than did the blackbirds at 0.12. An analysis of covariance between species regression lines reveals a significant difference between slopes (i.e., fat index, $P < 0.01$).

Our fat index versus age-in-days analysis shows a large scatter of data. This variance is partly related to the difficulty of aging nestlings more accurately than to within a 24 hour interval (Figure 2). The 0.002 variance for nestling sparrows during the first 6 days was twice as large as the 0.001 variance of the older individuals. By contrast, the blackbird nestlings exhibit no correla-

TABLE 1

Comparison of Mean Weights of the Major Body Components of House Sparrow and Red-winged Blackbird Nestlings of Three Age Groups

Age (Days)	*Dry-lean Weight (Grams)*	*Fat (Grams)*	*Fat Index*	*Water (Grams)*	*Water Index*
		House Sparrow			
1-5	1.1	0.1	0.1	8.5	7.7
6 - 10	3.3	0.5	0.2	17.9	5.4
11 - 15	4.8	0.8	0.2	20.8	4.3
		Red-winged Blackbird			
1 -3	0.9	0.1	0.1	8.5	9.4
4 - 6	2.5	0.2	0.1	15.8	6.3
7 - 9	5.3	0.6	0.1	23.8	4.5

tion ($P < 0.10$) between fat index and age. In other words, the ratio of fat to dry-lean changed little during development. Variance in fat index is, however, large at all stages of blackbird nestling development.

Water is also a dynamic body component of developing nestlings (Table 1). As would be expected, the water content of both species increased with age up to the time of fledging. A water index (water content divided by the dry-lean weight), however, is often used to express body water content. Since the dry-lean mass increases at a high rate in developing birds, one can observe in Table 1 that the water index declines with age of the individual. In terms of total body mass, the water content of the sparrow and blackbird decreased from 87 and 89 percent respectively down to 79 and 80 percent. Body water of adult birds would likely approach 66 percent.

Discussion

The fat to dry-lean ratio in nestling sparrows just prior to fledging was almost one-half higher than the ratio in Red-wing nestlings. The difference in fat between nestlings is probably related to the different time intervals spent in the nest by each species plus the size difference between species. House Sparrows fledge at about 14.4 days of age (Weaver, 1942). Body mass increases from 2.8 grams at hatching to about 26 grams at fledging for a growth rate of 1.6 grams per day. In contrast, female and male Red-wings respectively spend only 9.2 and 9.7 days in the nest (Holcomb and Twiest, 1970). The growth rate for females is 2.8 grams per day, whereas males grow at 3.0 grams per day. Body mass for the two sexes respectively increases from 5.0 grams at hatching (Williams, 1940) to 33 and 35 grams at fledging (Holcomb and Twiest, 1970). Thus both sexes of the blackbird achieve a larger body mass increment than the sparrows during a shorter time span (almost a twofold difference in growth rates). Since growth of the Red-wing nestling is relatively fast, it seems reasonable to find fat storage to be minimal. Energy intake in the blackbird is evidently channeled more into skeletal and nonfat tissue growth. In contrast, excess lipid deposition can occur in the nestling House Sparrow apparently because of its lesser energy demand for tissue growth.

The variance in the ratio of fat to dry-lean weight for the nestling House Sparrows (Fig. 1) was much lower for the nestlings under 2.49 grams than for those nestlings above that amount. Weaver (1942) suggests that as fledging approaches, the larger nestlings are found high in the nest and accordingly receive more food than do any smaller siblings. Since competition for food between siblings probably increases with age, it follows that some individuals receive more food than do others. As a result, some siblings would be able to store more fat (higher fat index), thus possibly accounting for the increased variance observed in the larger nestling size cohorts.

Although the data on Red-wings are few in the 5.00 to 7.00 gram dry-lean weight category (Fig. 1), it appears that the rate of fat deposition increases just prior to fledging, thus making the regression line somewhat curvilinear. As mentioned earlier, Brenner (1964) employed different methods on nestling Red-wings and obtained results similar to those of the present study. According to Brenner, the amount of fat deposited per gram of body weight decreased up to day seven and then increased rapidly until the time of fledging.

The large variance encountered in the fat index of nestling House Sparrows 6 days and under in age was undoubtedly due to the difficulty in correctly aging individuals to within a 24-hour period. Weaver (1943) found that the first 2 or 3 eggs in a clutch were incubated for about the same length of time. The other eggs usually hatched 12 to 24 hours later but always within 48 hours. With such a large time interval between the hatching of eggs, the first nestlings to hatch have a competitive developmental advantage over their siblings with respect to begging food from the parents. The nestlings hatching later may receive enough food to sustain life and increase their body mass, but may not receive enough food to store much energy in fat depots. As a result, the fat index of the nestlings to hatch last would be lower than that in the nestlings to hatch first, and hence one observes a large variance in the data. It appears that the nestlings hatching later, however, catch up with their older siblings in fatness during the last half of the nestling period. This probably occurs because the rapid increase in body mass appears to slow after about 6 days (Table 1). Slowing of the growth rate of the older siblings would allow the younger nestlings to receive more food and deposit more fat, thereby achieving about the same fat index as their older siblings.

Fat index did not increase with age for red-wing nestlings, whereas the sparrow regression was quite significant ($P < 0.01$). Ricklefs (1967), while comparing the lipid index of nestling Barn Swallows to that of nestling Red-winged Blackbirds, was puzzled by the low levels of lipid reserves found in the nestling blackbirds. It seems likely that the low lipid levels observed by Ricklefs as well as those observed in the present study were due to the rapid increase in nonfat body mass. In Table 1 the index for sparrows increased from 0.08 to 0.16, whereas the blackbird fat index increased from 0.08 to only 0.11. As mentioned previously, nestling Red-winged Blackbirds display a very high growth rate, and, therefore, do not accumulate fat to any appreciable extent. If the energy intake is just adequate to promote tissue growth, then the ratio of fat to metabolic body mass will likely remain the same with time. Any excess energy results in fat storage and reflects either large food energy sources or only moderate energy demands for tissue growth or a combination of these two factors. From Figure 2 it is evident that the Red-wing is of the first category with tissue growth being the highest metabolic priority, and the House Sparrow, with an increase in fat index with age, is of the second category, where surplus energy for fat storage is available.

References

Brenner, F. J., 1964, Growth, fat deposition, and development of endothermy in nestling Red-winged Blackbirds, Jour. of Sci. Laboratories, 46: 81-89.

Connell, C. E., E. P. Odum, and H. Kale, 1960, Fat-free weights of birds, Auk, 77: 1-9.

Cratin, P. D., 1970, Interfacial behavior of asphaltenes, Highway Research Record, 340: 29-37.

DeHaven, R. W., F. T. Crase, and M. R. Miller, 1974, Aging Tricolored Blackbirds by cranial ossification, Bird-Banding, 45: 156-159.

Helms, C. W., W. H. Aussiker, E. B. Bower, and S. D. Fretwell, 1967, A biometric study of major body components of the Slate-colored Junco, *Junco hyemalis,* Condor, 69: 560-578.

Hicks, D. L., 1967, Adipose tissue composition and cell size in fall migratory thrushes (Turdidae), Condor, 69: 387-399.

Holcomb, C., and G. Twiest, 1970, Growth rates and sex ratios of Red-winged Blackbird nestlings, Wilson Bull., 82: 294-303.

Nero, R. W., 1951, Pattern and rate of cranial ossification in the House Sparrow, Wilson Bull., 63: 85-88.

Odum, E. P., D. T. Rogers, and D. L. Hicks, 1964, Homeostasis of the nonfat components of migrating birds, Science, 143: 1037-1039.

Quigley, P., Methods of fat extraction, Unfinished M. S. thesis, Central Michigan University.

Ricklefs, R. E., 1967, Relative growth, body constituents, and energy content of nestling Barn Swallows and Red-winged Blackbirds, Auk, 84: 560-570.

Stewart, R. M., 1972, The reliability of aging some fall migrants by skull pneumatization, Bird-Banding, 43: 9-14.

Weaver, R. L., 1942, Growth and development of English Sparrows, Wilson Bull., 54: 183-191.

Weaver, R. L., 1943, Reproduction in English Sparrows, Auk, 60: 62-73.

Williams, J. F., 1940, The sex ratio in nestling Eastern Red-wings, Wilson Bull. 52: 267-277.